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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: John D. O'Sullivan et al.

Serial No.: 08/157,375

Filed : November 23, 1993 Art Unit 2603

For : WIRELESS LAN

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Name of Applicant, Assignee or Registered Representative

William S. Frommer
Signature

March 22, 1994
Date of Signature

530 Fifth Avenue
New York, New York 10036
March 22, 1994

The Commissioner of Patents and Trademarks
Washington, D. C. 20231

Sir:

To perfect applicants' claim to priority under 35 U.S.C. 119, enclosed is a certified copy of Application No. PL 6069, filed in Australia on November 27, 1992.

PATENT
457680-2010

Please charge any fees due to our Deposit Account No. 03-3925.

Respectfully submitted,

CURTIS, MORRIS & SAFFORD, P.C.

By William Frommer

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WSF:pd:WSF73.79
Enclosure

AUSTRALIA

Patent Office
Canberra

I, RONALD MAXWELL MAY, ASSISTANT DIRECTOR PATENT ADMINISTRATION, hereby certify that the annexed are true copies of the Provisional specification and drawing(s) as filed on 27 November 1992 in connection with Application No. PL 6069 for a patent by COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION filed on 27 November 1992.

I further certify that the annexed documents are not, as yet, open to public inspection.

WITNESS my hand this Twenty-Second day of November 1993.

RONALD MAXWELL MAY
DELEGATE OF COMMISSIONER OF PATENTS

S & F Ref: 223229

ORIGINAL

AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION FOR THE INVENTION ENTITLED:

A Wireless Lan

Name and Address of Applicant: Commonwealth Scientific and Industrial Research Organisation, a body corporate established by the Commonwealth Science and Industry Research Act 1949, of Limestone Avenue, Campbell, ACT, 2601, AUSTRALIA

This invention is best described in the following statement:

The present invention relates to local area networks (LAN's) which enable devices with computational ability to communicate with each other and, in particular, to a wireless LAN in which the devices communicate by means of radio transmissions.

In recent years the personal computer has become an increasingly important tool in business and commerce and many workers now spend a good portion of their working day operating such computers. Similarly, business organisations are increasingly structuring their businesses to not only enable, but to oblige, their workers to access information by means of a personal computer or equivalent terminal, which is connected to a local area network which extends around or through the office environment.

Hitherto such local area networks have been provided either by electrical conductor or optical fibre and this requires the office premises to be extensively cabled. This cabling must be adjusted if, for example, partitions within an office are to be adjusted. In addition, the cabling required for a classroom or tutorial arrangement where a large number of personal computers are intended to be operated within a small areas, can be quite substantial.

Furthermore, an increasing trend in recent times has been the sale of mobile or portable devices with computational ability. These include both laptop/notebook and handheld computers. Whilst the primary impetus for the purchase of such a computer is the ability to use its computational power outside of the normal office environment, once a portable computer has been purchased, the desire arises to use the portability within the office premises so as to allow the user of the portable computer to take the computer with him and use it in the closely adjacent offices of colleagues, for example, and yet still be able to access the LAN of the business organisation, which may be spread over several adjacent buildings in "campus" style.

While this is possible by means plug-in connectors which enable the portable computer of one operator to be plugged into the office LAN at any particular location, it is generally inconvenient since the LAN may not provide for two or more points of connection within a single office, the portable computer loses its portability, and so on.

Accordingly, the need arises for a LAN to which such portable devices can be connected by means of a wireless or radio link.

Such wireless LAN's are known, however, hitherto they have been substantially restricted to low data transmission rates. In order to achieve widespread commercial acceptability, it is necessary to have a relatively high transmission rate and therefore transmit on a relatively high frequency, of the order of 1 GHz or higher. As will be explained hereafter, radio transmission at such high frequencies encounters a collection of unique problems.

One wireless LAN which is commercially available is that sold by Motorola under the trade name ALTAIR. This system operates at approximately 18 GHz, however, the maximum data transmission rate is limited to approximately 3-6 Mbit/s. A useful review of this system and the problems of wireless reception at these frequencies and in "office" environments is contained in "Radio Propagation and Anti-multipath Techniques in the WIN Environment", James E. Mitzlaff IEEE Network Magazine November 1991 pp. 21-26.

This engineering designer concludes that the inadequate performance, size, expense and power consumption of the hardware needed to adaptively equalize even a 10 Mbit/s data signal are such that the problems of multipath propagation cannot thereby be overcome in Wireless In-Building Network (WIN) systems. Similarly, spread spectrum techniques which might also be used to combat multipath problems consume too much bandwidth (300 MHz for 10 Mbits/s) to be effective. A data rate of 100 M/bit/s utilizing this technology would therefore consume 3 GHz of bandwidth.

Instead the solution adopted by Motorola and Mitzlaff is a directional antenna system with 6 beams for each antenna resulting in 36 possible transmission paths to be periodically checked by the system processor in order to locate the "best quality" path and "switch" the antennae accordingly. This procedure adds substantial bulk and cost to the system. This procedure is essentially the conversion of a multipath transmission problem into a point-to-point transmission environment by the use of directional antennae.

The object of the present invention is to provide a wireless LAN in a multipath transmission environment having a high bit rate such that the reciprocal of the data or information bit rate (the data "period") is short relative to the time delay differences between significant transmission paths.

According to one aspect of the present invention there is disclosed a wireless LAN comprising a plurality of hub transceivers each connected together to constitute a data source and/or destination, and a plurality of mobile transceivers each able to communicate by radio transmissions with any one(s) of said hub transceivers within a predetermined range, wherein each of said mobile transceivers are connectable to, and able to be powered by, a corresponding portable electronic device with computational ability, said radio transmissions have a frequency in excess of 10 GHz, and all the transceivers are configured to receive and transmit in a multipath transmission environment, the reciprocal of the information bit rate of said transceiver's transmission being short relative to the time delay differences between significant ones of the transmission paths of said multipath transmission environment.

According to another aspect of the present invention there is disclosed a peer-to-peer wireless LAN having a plurality of mobile transceivers each able to communicate by radio transmission with any other like transceiver within a predetermined range, wherein each of said mobile transceivers are connectable to, and able to be powered by, a corresponding portable electronic device with computational ability, said radio transmissions have a frequency in excess of 10 GHz, and all the transceivers are configured to receive and transmit in a multipath transmission environment, the reciprocal of the information bit rate of said transceiver's transmission being short relative to the time delay differences between significant ones of the transmission paths of said multipath transmission environment.

According to a still further aspect of the present invention there is disclosed a method of transmitting data between at least one hub transceiver and a plurality of mobile transceivers within a predetermined cell range or between said mobile transceivers, wherein said data transmission is a multipath transmission having a frequency in excess of 10GHz, each said mobile transceiver is connected to, and is powered by, a corresponding portable electronic device with computational ability, and the reciprocal of the information bit rate of said transmissions is short relative to the time delay differences between significant ones of the transmission paths of said multipath transmission.

Preferably, transmission is enhanced by the use of one or more of the following techniques, namely interactive channel sounding, forward error correction with redundancy sufficient for non-interactive correction, modulation with redundancy sufficient for interactive error correction by re-transmission of at least selected data, and the choice of allocation of data between sub-channels.

The radio transmission is also preferably divided into small packets of data each of which is transmitted over a time period in which the transmission characteristics over the predetermined range are relatively constant.

The encoding of the data is preferably carried out on an ensemble of carriers each costituting a sub-channel and having a different frequency with the modulation of each individual carrier preferably being multi-level modulation of carrier amplitude and/or phase (mQAM). The modulation family mQAM includes amplitude shift keying (ASK), multi-level ASK (mASK), binary phase shift keying (BPSK), multi-level phase shift keying (mPSK), amplitude phase keying (APK), multi-level APK (mAPK) and the like.

Embodiments of the present invention will now be described with reference to the drawings in which:

Fig. 1 is a schematic plan view an office illustrating multipath transmissions of radio frequencies of at least 10 GHz caused by reflections;

Fig. 2 is a graph of received power as a function of time, for a brief transmission, illustrating the received signals of reduced magnitude which are delayed owing to the possibility of multiple path transmission;

Fig. 3 is a graph of the received amplitude of such signals as a function of the transmitted frequency, this characteristic itself being time dependent;

Fig. 4 is a schematic diagram illustrating a local area network including a plurality of hubs each of which is able to communicate with mobile transceiver(s) within a corresponding cell;

Fig. 5 is a schematic block diagram of the circuit arrangements within each hub and mobile transceiver; and

Fig. 6 is a more detailed block diagram illustrating part of the mobile transceiver of Fig. 5.

In schematic form, Fig. 1 illustrates a room 1 in a typical office environment which includes items of furniture 2 and a transmitter 3 and receiver 4. For radio transmissions at a frequency in excess of 10 GHz, a multipath mode of transmission from the transmitter 3 to the receiver 4 occurs. Reflections from the walls (and floor and ceiling) of the room 1, items of furniture 2, and the like, within the room 1 cause the multiple path transmissions.

As illustrated in Fig. 2, the effect of the multiple path transmissions is that the receiver 4 receives an undelayed signal 5 which has travelled directly from the transmitter 3 to the receiver 4, and a number of delayed signals 6 which are received at a time after receipt of the undelayed signal 5. The magnitude of the delayed signals 6 is usually somewhat attenuated. Under some conditions, the magnitude of the undelayed signal 5 can be attenuated also, sometimes by more than some delayed signals 6.

As a consequence of the delayed signals 6, it is necessary for the length of time during which a single symbol is transmitted (the symbol period) to be substantially longer than the delay time in order that the received echoes of a first symbol not mask the receipt of a subsequent symbol. This requirement has provided a severe upper limit to the rate at which data can be transmitted in such an environment.

Furthermore, as illustrated in Fig. 3, the office environment is by no means a good one for radio transmission. Fig. 3 illustrates a typical channel characteristic illustrating the magnitude of the received signal as a function of frequency in the 1 GHz band between 60 and 61 GHz. It will be seen that the received amplitude is by no means constant and, in particular, at various frequencies fading occurs. Furthermore, as indicated by dotted lines in Fig. 3, the frequency at which fading occurs varies as a function of time because of movements within the room. Such a communication channel is called a time varying frequency selective fading channel.

Similar, but different, communications channels are known in both telephone and long distance radio communications and various strategems, generally known as equalisation, are used to overcome them. However, in these fields since such fading is due to changes in temperature, or atmospheric conditions, once such telephone or long distance radio communication channels are established, the fading

characteristic changes relatively slowly. Also in telephone applications advantage of the fact that channel degradation is generally low near the centre of the channel, can be taken when arranging the equalisation. This is not the case in an office or indoor environment.

Rather, in the above described office environment, the change in the transmission characteristic indicated by dotted lines in Fig. 3 can, for example, be caused by the simple act of someone opening a briefcase positioned on a desk. The raised lid of the briefcase results in a rapid change in the characteristic. Similar extremely short term changes can be caused by the receiver 4 itself moving, or other objects moving such as doors opening, people moving, and the like. The foregoing establishes a very hostile environment within which the desired radio transmissions are to take place. In particular, there is no preferred channel or even a guaranteed channel within the 1 GHz band.

It would be possible to overcome the abovementioned difficulties by the use of highly directional antennas so as to eliminate all paths of transmission but the direct path. However, attempting to mechanically align such an antenna which was in turn affixed to a portable computer is commercially unattractive.

Fig. 4 illustrates in schematic form the general layout of a wireless LAN in accordance with a preferred embodiment of the present invention. A plurality of hubs 8 and mobile transceivers 9 are provided. The hubs 8 are interconnected by means of a backbone 10 which can take the form of either electrical conductors or optical fibre cable. As indicated by a dotted line in Fig. 4 the backbone 10 can constitute a loop. If desired, the backbone 10 can be connected to other computers 7 and, if desired, via a gateway 11 to the public switched telephone network 12. In a typical arrangement, each office (or each office in each building of a campus) would be provided with a single hub 8 which would communicate with the, or each of the, mobile transceivers 9 in that room. Either the backbone 10 can extend over the entire area to be covered, or the area can be covered by the use of multiple gateways and multiple backbones. The effective range of the transceiver within the hub 8 is arranged to essentially cover only that room. The limited transmission range for the hub 8 creates a

corresponding cell 13 as indicated by broken lines in Fig. 4. For a large room such as a lecture room in an educational institution, the length of the room can require that the room be provided with two hubs 8 in which case two partially overlapping cells 13 would be present within the one room.

As seen in Fig. 5, for the hub transceiver 8, a number of component blocks are provided. These take the form of a network interface 20, a buffer memory 21, a framing and forward error correction section 22, a modulator/demodulator 23, an intermediate frequency section 24, a receiver 25, a transmitter 26, and an antenna 27 which is sufficiently omnidirectional to illuminate the entire cell 13. The antenna 27 can achieve this result statically or dynamically (with electronical or mechanical beam steering). All these items are connected to, and are operable by, a control and timing section 28.

Equivalent portions of the mobile transceiver 9 are indicated by a designator having a magnitude higher by 10 in Fig. 9. It will be noted that the antenna 37 is preferably a steerable antenna which is electronically steerable by the control and timing section 38 so as to at least partially direct the transmissions to and from the mobile transceivers 9 towards the corresponding hub 8. This improves the signal to noise ratio on the wireless link and attenuates delayed signals thereby improving multipath performance.

A more detailed block diagram of a portion of the transceiver 9 is illustrated in Fig. 6 from which it will be seen that the preferred form of modulation includes not only encoding but also fast fourier transforming, and its inverse. The transceiver 35,36 is preferably realised by means of one or more monolithic integrated circuits. Furthermore, in order to reduce power consumption in the mobile transceiver 9, the control and timing section 38 powers down each mobile transceiver 9 except when it is transmitting or receiving. This is determined by a polling scheme initiated by the hub transceivers 8. For example, the hub 8 can communicate with each mobile transceiver 9 in turn inquiring if any data is required to be transmitted or access to other parts of the LAN is required. This polling of the various stations can comprise one of a number of standard techniques such as time division multiple access, ALOHA or slotted ALOHA, timed token passing, grant request schemes or other applicable techniques.

The transmissions from the various transceivers 8and 9 which comprise the network need not necessarily be at the same bit rate since some portions of the network need only a low speed of transmission (eg. printers) while others require a very high speed of transmission. This embodiment enables a variety of rates of transmission to be accommodated in a compatible network. This enables lower cost and/or low power consumption transceivers 9 to be used for printers or low data rate computing devices.

In order to provide a high speed bit transmission rate in the hostile radio environment as described above, two techniques are used simultaneously. The first is to transmit over a relatively large number of parallel sub-channels within the available bandwidth so that each channel has a low bit rate but the total, or overall bit rate, is high. This overcomes the problem of delay time. The information is discretely allocated across a relatively broad frequency range which ameliorates the problems caused by nulls in channel transmission characteristics. This is assisted by having the channel spacings small compared to the characteristic widths of the nulls.

The second technique involves the transmission of the data in small packets having some form of data reliability enhancement. The length of the packet depends upon the method of data reliability enhancement and the hostility of the environment. Each packet is able to be transmitted under different channel conditions, thereby addressing the problem of the rapid time change of the channel characteristics.

In the most favourable environment, use of only ensemble modulation (the first technique) may be sufficient to produce an adequate result. However, such environments are rarely encountered and therefore, in practice, the second technique must be employed in combination with the first technique.

The initial form of the second technique is data reliability enhancement by automatic repeat request (ARQ). The maximum permissible packet length able to be chosen is that which will ensure a practical probability of error free transmission. As the hostility of the environment increases, either channel sounding or a redundancy arrangement such as forward error correction (FEC), and/or data redundancy, and/or permutation modulation should be also used. If

necessary, both channel sounding and redundancy technique(s) can be used.

In relation to the first of these techniques, typical time delays due to multipath transmission are of the order of 100 ns because of the dimensions of typical rooms. At a desired bit rate of the order of 100 Mbit/s, this indicates that the bit period is 10 ns which is only 10% of the delay time. However, if the transmission is divided into, say, thirty sub-channels, then in order to achieve a bit rate of 100 Mbit/s overall, this implies that each channel must have a bit rate of approximately 3.3 Mbit/s. If 30 bits are sent as a symbol, then the symbol time is of the order of 300 ns which is greater than the delay time.

In relation to the second technique, because of the fading channel, not all the sub-channels can be expected to transmit successfully. For this reason data error correction is provided. This takes a number of forms. The first is redundancy sufficient for the detection of errors so that there may be subsequent re-transmission of at least selected data in which those passages of information not correctly received are re-sent. The re-transmission is not necessarily over the same channel. The second is forward error correction which has a redundancy sufficient for non-interactive correction. A third is permutation modulation such as multi-tone amplitude shift keying which has built-in redundancy. Any of these techniques allow the demodulator to correct for a relatively small percentage of errors in the received bits.

The preferred type of modulation in each sub-channel is multi-level modulation of carrier amplitude and/or phase (mQAM). The modulation family mQAM includes amplitude shift keying (ASK), multi-level ASK (mASK), binary phase shift keying (BPSK), multi-level phase shift keying (mPSK), amplitude phase keying (APK), multi-level APK (mAPK) and the like.

Transceivers 9 for devices such as printers which require a lower bit rate transmission can use the techniques which give a lower spectral efficiency such as amplitude shift keying (ASK).

In the case of ASK, the transmission is m-ary where a transmitted symbol can encode $\log_2 m$ binary digits. There is an alphabet of m symbols allocated to the channel. Each symbol transmitted has a built

in redundancy so that if several of the symbols are received in error due to the poor nature of the corresponding part of the channel, a correct decision can still be made as to which of the allowed symbols was transmitted.

A choice of the symbols with the appropriate orthogonality can be made using a number of well known information theory techniques or by a computer search for the appropriate codes. Due to the high redundancy and limited bandwidth efficiency of amplitude shift keying this system does not yield a high spectral efficiency (expressed as bits/Hz). For the system of the illustrated embodiment this can be lower than 0.25 bit/Hz. It is, however, relatively simple to implement and so is desirably used in a lower cost, lower bit rate transceiver 9 for printers, for example, which are compatible with the higher performance embodiments described below.

Another embodiment of the multi-carrier scheme is to phase modulate each carrier using a phase shift keying (PSK). In simple embodiments this is binary phase shift keying (BPSK) where two phase options are transmitted or quadrature phase shift keying (QPSK) where four options are transmitted. Any higher number can be transmitted as required.

In the BPSK embodiment, the data stream at a bit rate b is split into p parallel paths resulting in a symbol of duration p/b seconds. These symbols are then encoded using a conventional forward error correction scheme such as, but not restricted to, Reed-Solomon coding. Such a code increases the number of bits which are required to be transmitted by a factor r. This is reciprocal of the coding rate. This would then result in a longer symbol having a duration, T, where $T = (p.r)/b$ seconds. Each such symbol consists of N bits where $N = p \, . \, r$. This symbol again consists of a number of one's or zero's which are used to modulate each of the p corresponding carriers. The resulting signal is transmitted over the channel and received by the other unit. Some of the sub-channels will be transmitted without error and some will be transmitted with significant errors due to the frequency selective nature of the channel.

The received carriers are detected and demodulated resulting in a symbol which is again N bits long. This symbol is decoded by a device

(such as a Reed Solomon decoder) and the errors in the received signal are normally completely corrected by this decoding process. Additionally, a weighting can be given as to the confidence of the accuracy of the output of each BPSK demodulator based upon the amplitude of the received carrier. This weighting can be used as an additional input to the decoding device to determine which bits are more likely to be in error and to increase the performance of this device in correcting as many errors as possible in the transmission.

The above will improve the error rate performance of the system, however, it will not eliminate all errors in all cases. To overcome any residual errors in the system an additional error correction layer can be used which requests the re-transmission of these symbols which are believed to be in error. This re-transmission can occur over the same frequency channel, or a request can be made to the control and timing section to shift the entire frequency channel by some predetermined amount, or to change antenna characteristics such as polarisation, to increase the probability of error free transmission.

It is also possible to use multiple level phase shift keying modulation on each of the carriers transmitted and a corresponding demodulator on the receiver. This will give improved bandwidth efficiency and therefore allow much higher data rates to be transmitted through the channel for the same compatible bandwidth. This option allows higher bit rate units to occupy the same spectrum as the lower bit rate transceivers but in a compatible manner. The increased spectral efficiency is acquired at the cost of increased complexity in the modulators and demodulators.

Because of the highly time variable nature of the transmission channel, the transmitted data is divided into packets of short duration (typically 100 microseconds). During this short time period it is satisfactory to assume that the transmission characteristics are essentially stationary. Before transmission of a packet data, it is possible to use a channel selection technique to reduce error rates. One channel selection technique is to channel sound prior to transmission of the packet. If necessary, this allows the data rate to be reduced if a particular channel is found to be degraded.

The foregoing describes only some embodiments of the present

invention and modifications can be made thereto without departing from the scope of the present invention. For example, interleaving and bit reversal of the transmitted data to decrease the received error rate can be accomplished by utilizing the bit reversal inherent in the FFT conversion. Also the antenna 37 can utilize polarisation diversity to improve reception.

One arrangement for the simultaneous operation of low bit rate transceivers and high bit rate transceivers is to allocate, say, half available (high bit) channel to the low bit rate transceivers. Thus, the low bit rate transceivers utilize only half of the available bandwidth and a hub can transmit data at the low rate to two low bit rate transceivers at the same time. Thus the same hub hardware is used for both high bit and low bit rate transmissions.

It will be clear to those skilled in the art that the LAN need not incorporate hubs 8 since the mobile transceivers 9 can transmit to, and from, each other directly within the predetermined cell rangê. Such a LAN is termed a peer-to-peer LAN.

Similarly, the hubs 8 although described as being interconnected by electric cable and/or optical fibre, can also be inter-connected by a radio or infra-red link. The link can form a part of the backbone 10 or constitute the inter-hub communication link.

The invention is summarised by the following paragraphs:

1. A wireless LAN comprising a plurality of hub transceivers each connected together to constitute a data source and/or destination, and a plurality of mobile transceivers each able to communicate by radio transmissions with any one(s) of said hub transceivers within a predetermined range, wherein each of said mobile transceivers are connectable to, and able to be powered by, a corresponding portable electronic device with computational ability, said radio transmissions have a frequency in excess of 10 GHz, and all the transceivers are configured to receive and transmit in a multipath transmission environment, the reciprocal of the information bit rate of said transceiver's transmission being short relative to the time delay differences between significant ones of the transmission paths of said multipath transmission environment.

2. A peer-to-peer wireless LAN having a plurality of mobile transceivers each able to communicate by radio transmissions with any other like transceiver within a predetermined range, wherein each of said mobile transceivers are connectable to, and able to be powered by, a corresponding portable electronic device with computational ability, said radio transmissions have a frequency in excess of 10 GHz, and all the transceiver's transmission are configured to receive and transmit in a multipath transmission environment, the reciprocal of the information bit rate of said transceivers being short relative to the time delay differences between significant ones of the transmission paths of said multipath transmission environment.

3. A method of transmitting data between at least one hub transceiver and a plurality of mobile transceivers within a predetermined cell range or between said mobile transceivers, wherein said data transmission is a multipath transmission having a frequency in excess of 10GHz, each said mobile transceiver is connected to, and is powered by, a corresponding portable electronic device with computational ability, and the reciprocal of the information bit rate of said transmissions is short relative to the time delay differences between significant ones of the transmission paths of said multipath transmission.

4. The arrangement as set forth in any one of paragraphs 1-3 above, wherein the transmission is enhanced by the use of one or more

of the techniques selected from the group of techniques consisting of: interactive channel sounding; forward error correction with redundancy sufficient for non-interactive connection; modulation with redundancy sufficient for interactive error correction by re-transmission of at least selected data; and the choice of allocation of data between channels.

5. The arrangement as set forth in paragraph 4 above, wherein for interactive channel sounding, the transmission is divided into small packets of data each of which is transmitted over a time period in which the transmission characteristics over said predetermined range are relatively constant.

6. The arrangement as set forth in any one of paragraphs 1 to 5 above, wherein the coding of data is carried out on an ensemble of carriers each of a different frequency.

7. The arrangement as set forth in paragraph 6 above, wherein the modulation of each individual carrier is multi-level modulation of carrier amplitude and/or phase (mQAM).

8. The arrangement as set forth in paragraph 7 above, wherein said mQAM is form the modulation family consisting of: amplitude shift keying (ASK), multi-level ASK (mASK); binary phase shift keying (BPSK); multi-level phase shift keying (mPSK); amplitude phase keying (APK); and multi-level APK (mAPK).

DATED this TWENTY-SEVENTH day of NOVEMBER 1992
Commonwealth Scientific and Industrial Research Organisation

Patent Attorneys for the Applicant
SPRUSON & FERGUSON

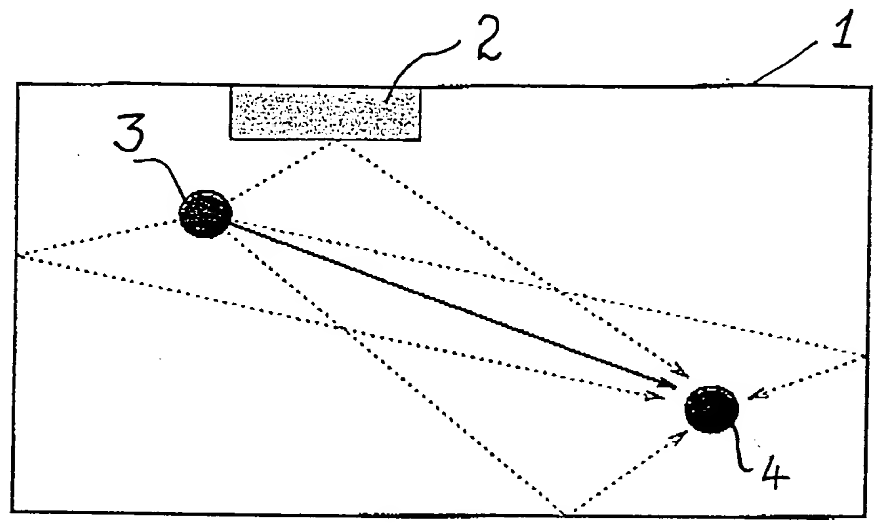


Fig 1:

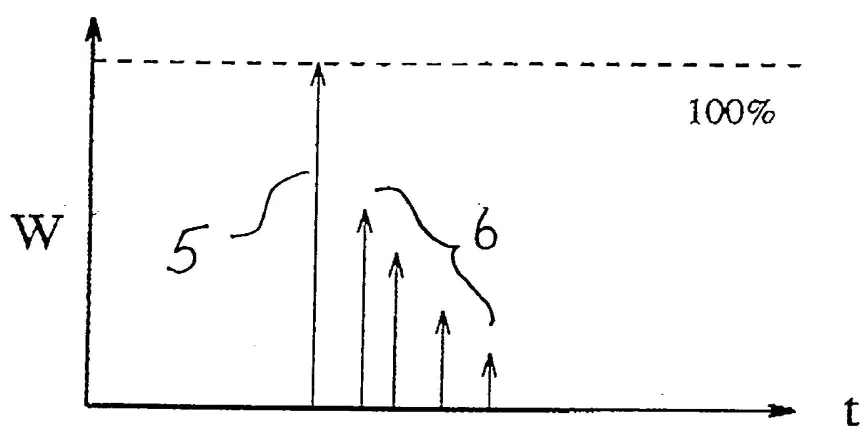
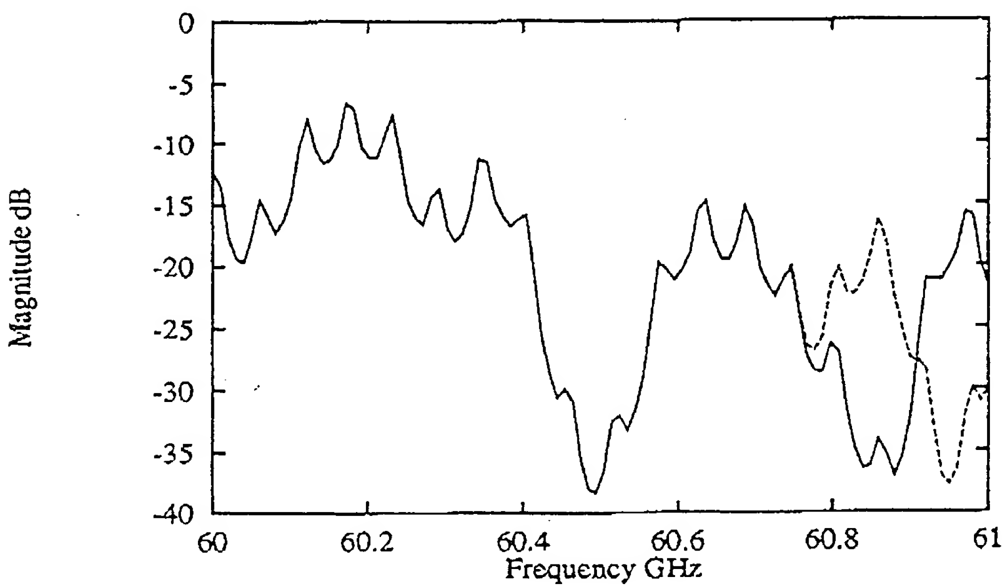


Fig 2:



0
-5
-10
-15
-20
-25
-30
-35
-40
Magnitude dB
60
60.2
60.4
60.6
60.8
61
Frequency GHz

Fig 3:

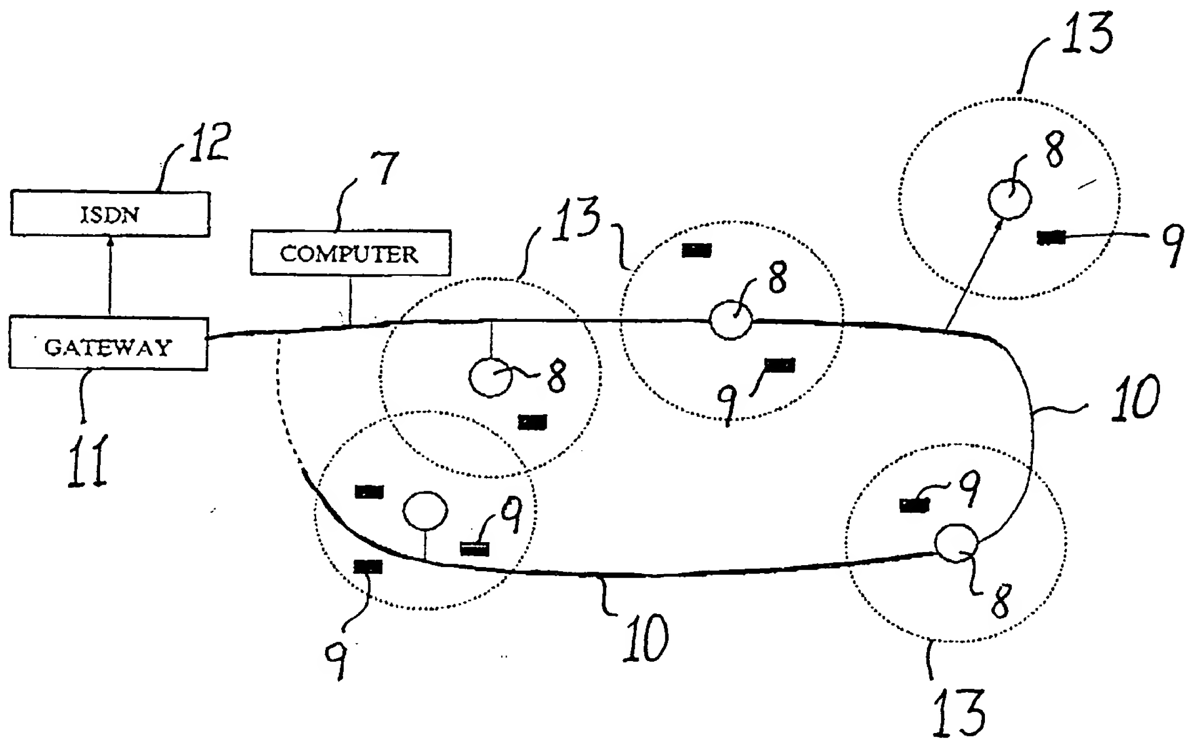
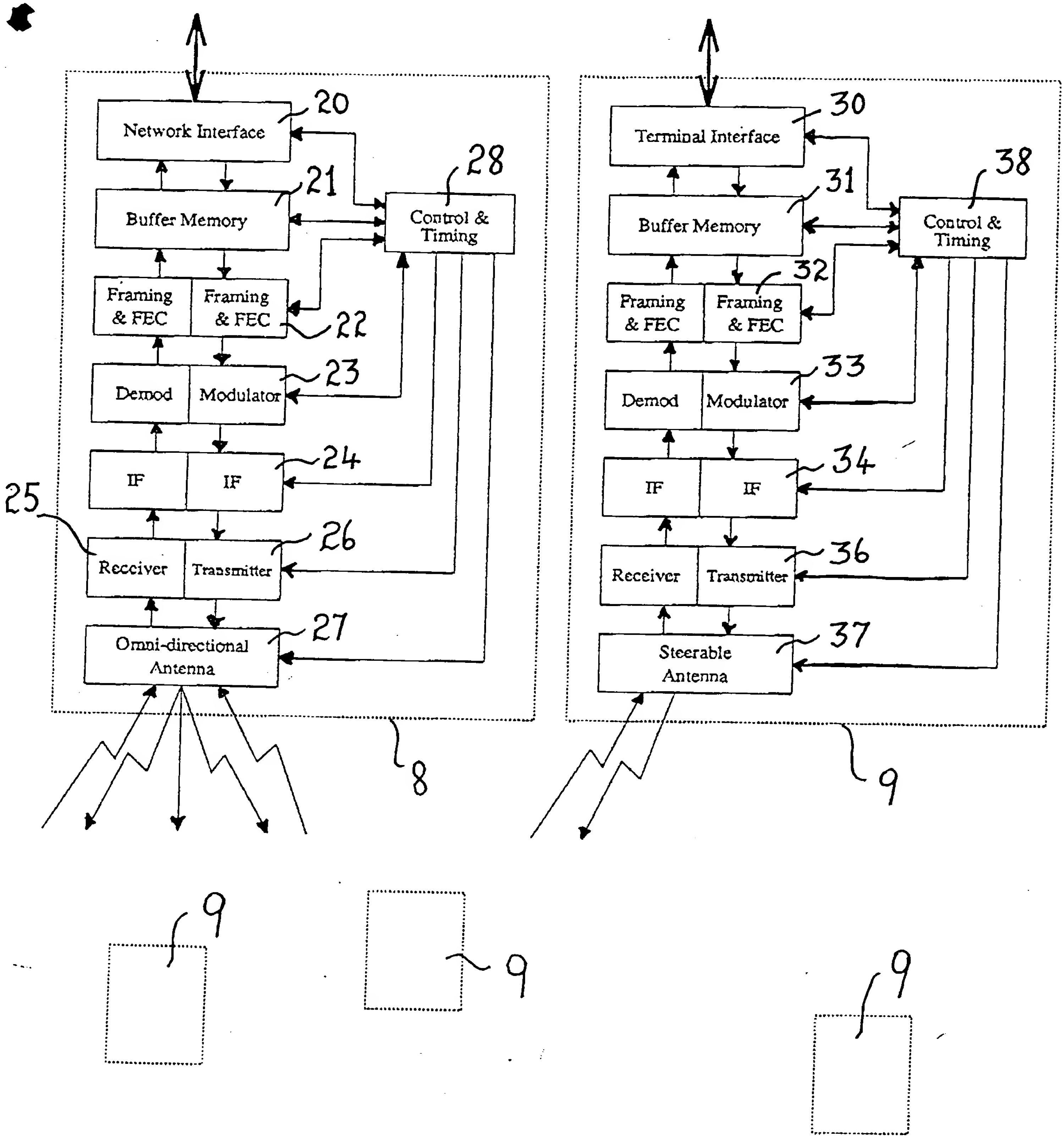


Fig. 4:



Network Interface
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Buffer Memory
21
Control & Timing
28
Framing & FEC
Framing & FEC
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Demod
Modulator
23
IF
IF
24
25
Receiver
Transmitter
26
Omni-directional Antenna
27
8
Terminal Interface
30
Buffer Memory
31
Control & Timing
38
Framing & FEC
Framing & FEC
32
Demod
Modulator
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IF
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Receiver
Transmitter
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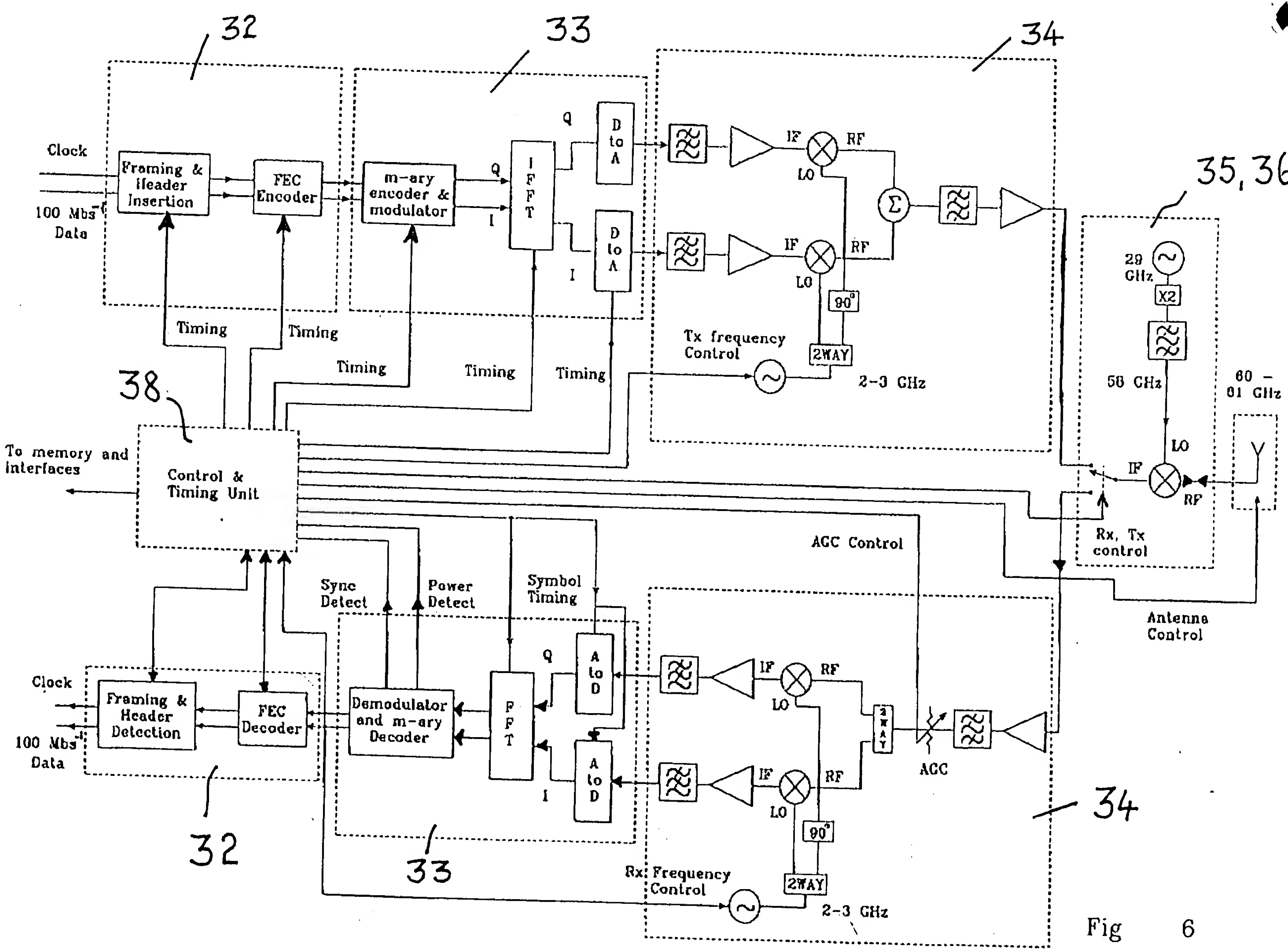
Steerable Antenna
37
9
9
9
9

Fig 5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33
34
35, 36
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32
33
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Clock
100 Mbs⁻¹ Data
Framing & Header Insertion
FEC Encoder
m-ary encoder & modulator
Q
I
I F F T
D to A
D to A
Timing
Timing
Timing
Timing
Timing
IF
LO
RF
90°
2WAY
Tx frequency Control
2-3 GHz
29 GHz
X2
58 GHz
60 - 61 GHz
LO
IF
RF
Rx, Tx control
To memory and interfaces
Control & Timing Unit
AGC Control
Antenna Control
Sync Detect
Power Detect
Symbol Timing
Clock
100 Mbs⁻¹ Data
Framing & Header Detection
FEC Decoder
Demodulator and m-ary Decoder
F F T
A to D
A to D
2WAY
ACC
Rx Frequency Control
2-3 GHz

Fig 6